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Resolving Cyclic Vibration on an Instrument Air Compressor

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- With GE-BN Machinery Diagnostics Services Group since 2007
- Project Engineer- Rockwell Automation-Entek IRD

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- Global Director, GE-BN, Machinery Diagnostics Services, Nantes France
- With GE-BN Machinery Diagnostics Services Group since 2006
- Worldwide Startup Activities Site-In-Charge, Alstom (Steam Turbine) & Cryostar (expander/compressor)
- Operation & Maintenance Engineer- PPG Industry, USA
- Mechanical/Acoustical Research Engineer, Technion, Haifa and TU Berlin

Case Study on Resolving Cyclic Vibration on an Instrument Air Compressor Train

Instrument Air Compressors are considered critical equipment in the plants, supplying compressed air to the instrumentations in the field. This case study focuses on cyclic vibration phenomena observed in the 2nd and 3rd stages of an Instrument Air Compressor, part of an Integral Gear Compressor train driven by a motor. The machine train is equipped with an online vibration monitoring and protection system with online diagnosis software, which was used to diagnose the phenomena & forward path for the resolution.

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- Machine Train Details
- Observation/Analysis
- Conclusions & Recommendations
- Machine Inspection Findings
- Corrective Actions / Lesson Learned

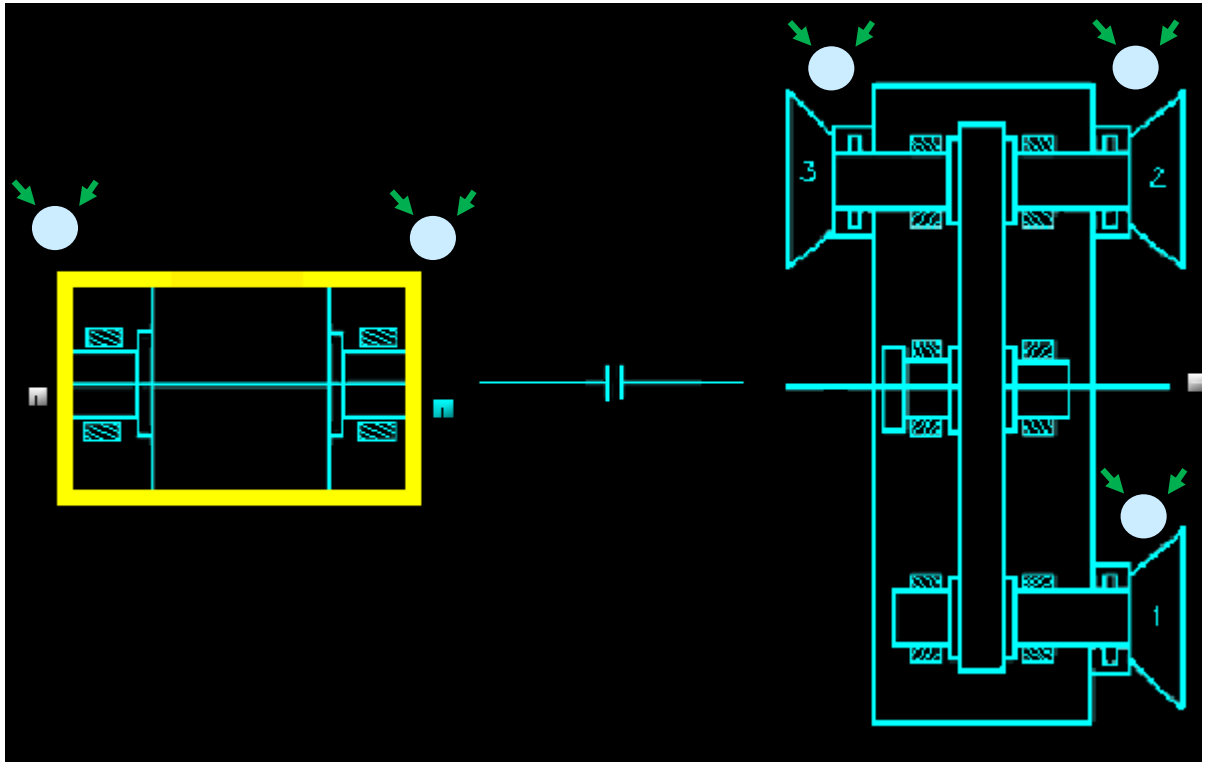
Problem Statement

- 3-stage integrally-geared instrument air compressor train experienced cyclic vibration.

- Phenomena noticed on 2nd & 3rd stage bearings with first observation during April 2013 and persisted till major overhauling in September 2014.

- From September 2013 onwards, the vibration amplitudes of 3rd stage intermittently reached alarm limits & Machine availability became a concern for the customer.

Machine Train Details



Operating Speeds

Pinions

1st Stage - 35793 rpm

2nd Stage - 52063 rpm

3rd Stage - 52063 rpm

Motor/Bull Gear Speed

2975 rpm

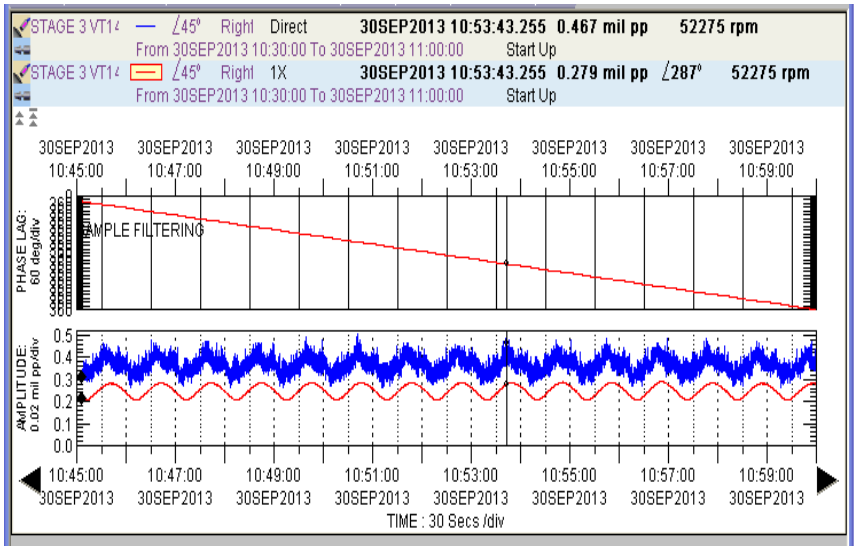
Critical Speeds

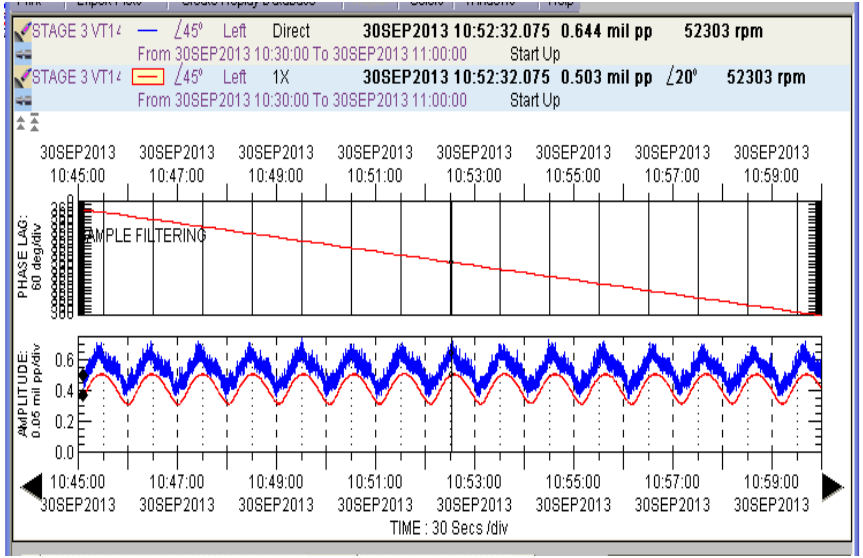
1st Stage - 21000 rpm

2nd /3rd Stage - 30800 rpm

Observations/Analysis

Direct & 1X Vibration Trend for 3rd Stage:

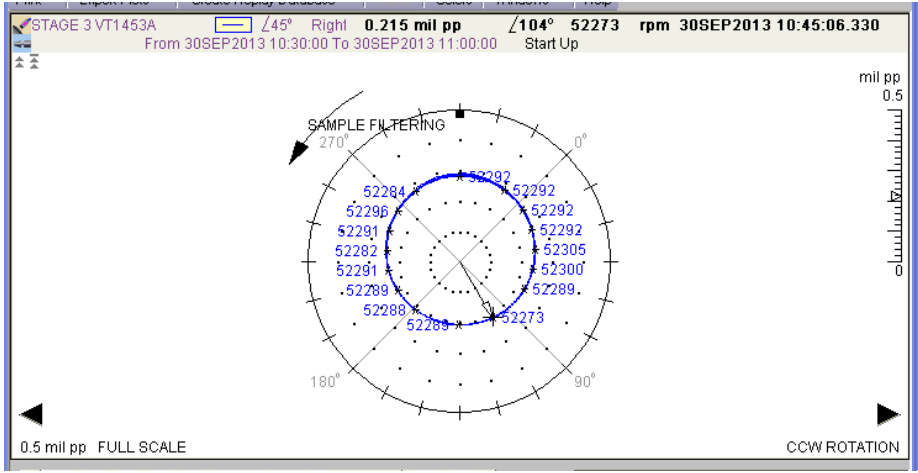


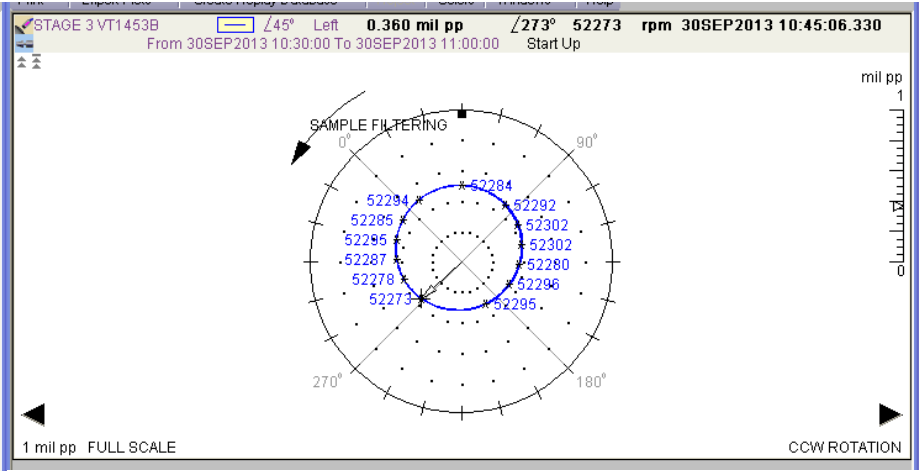


Abnormal periodic fluctuations of Direct and 1X vibration, repeating each cycle at 1 minute interval.

Observations/Analysis

1X Polar Plot of 3rd Stage Bearing: Steady State Condition

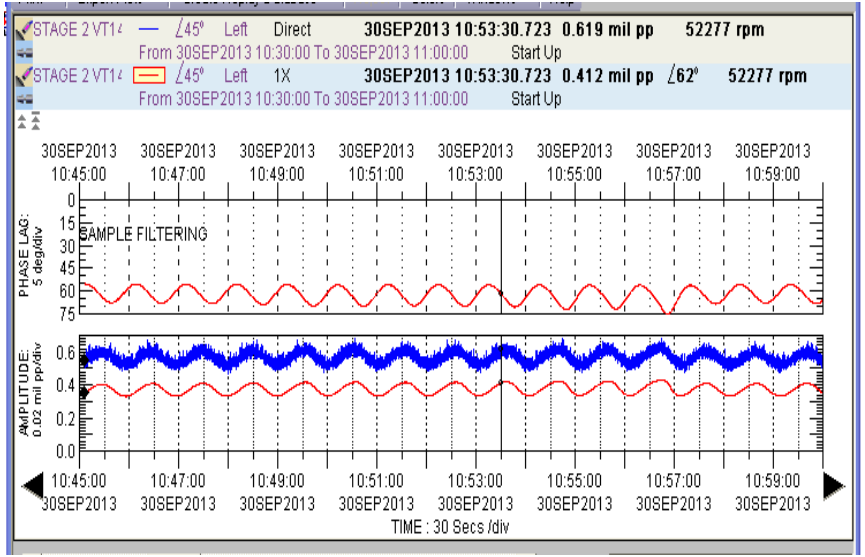


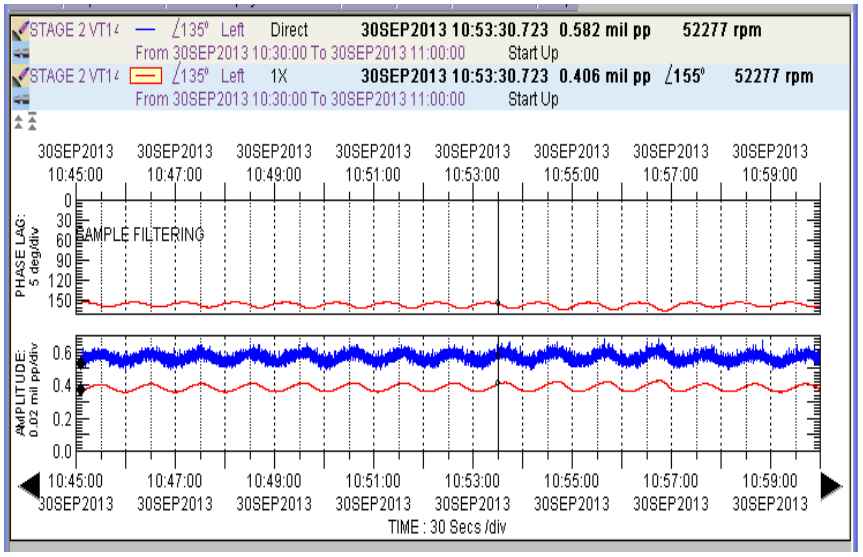


Abnormal 360-degree 1X phase angle revolutions

Observations/Analysis

Direct & 1X Vibration Trend of 2nd Stage:





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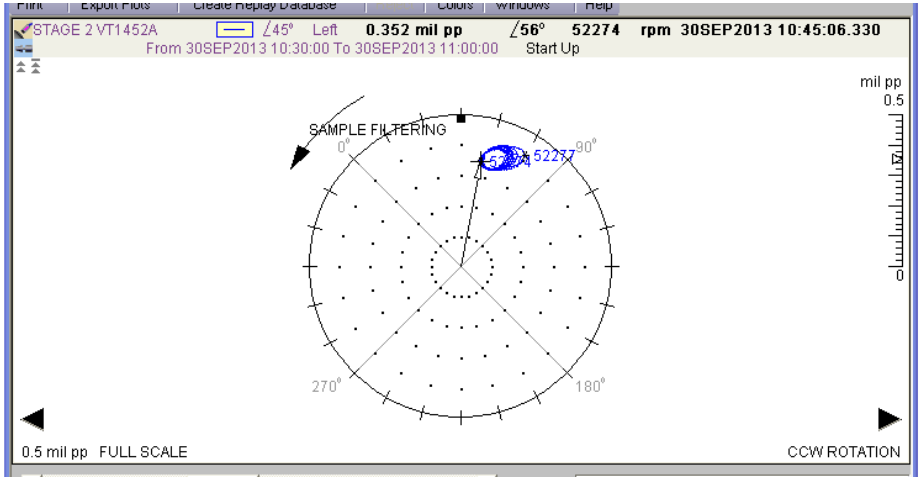
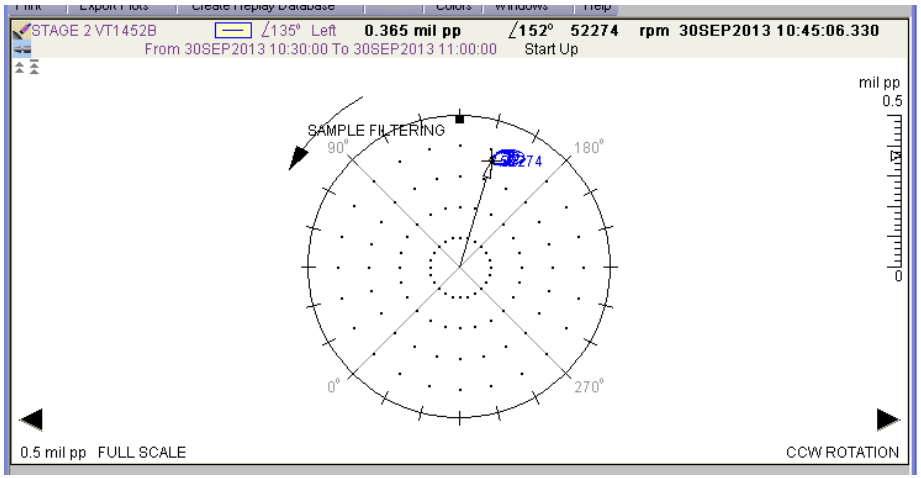
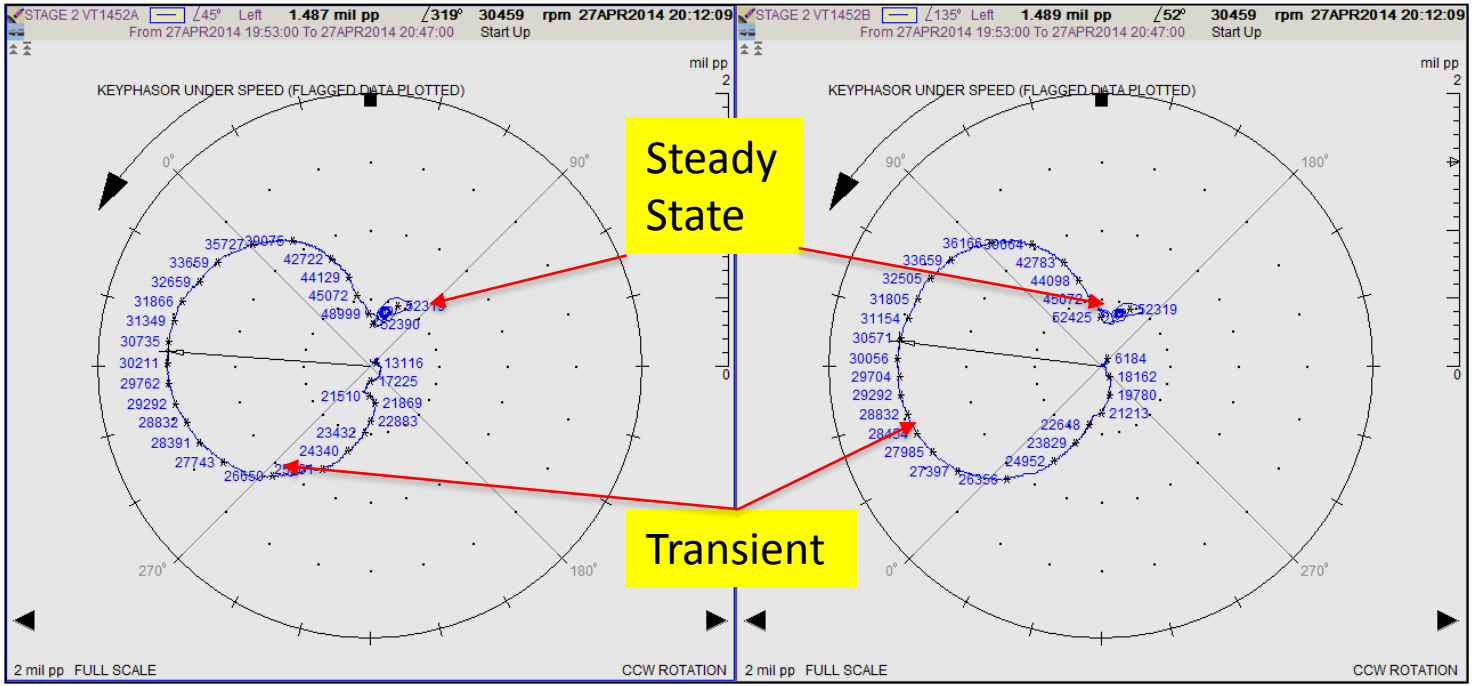




1X phase angle observed to revolve at one particular quadrant.

Observations/Analysis

Transient & Steady State- 1X Polar Plots of 2nd Stage Bearing:

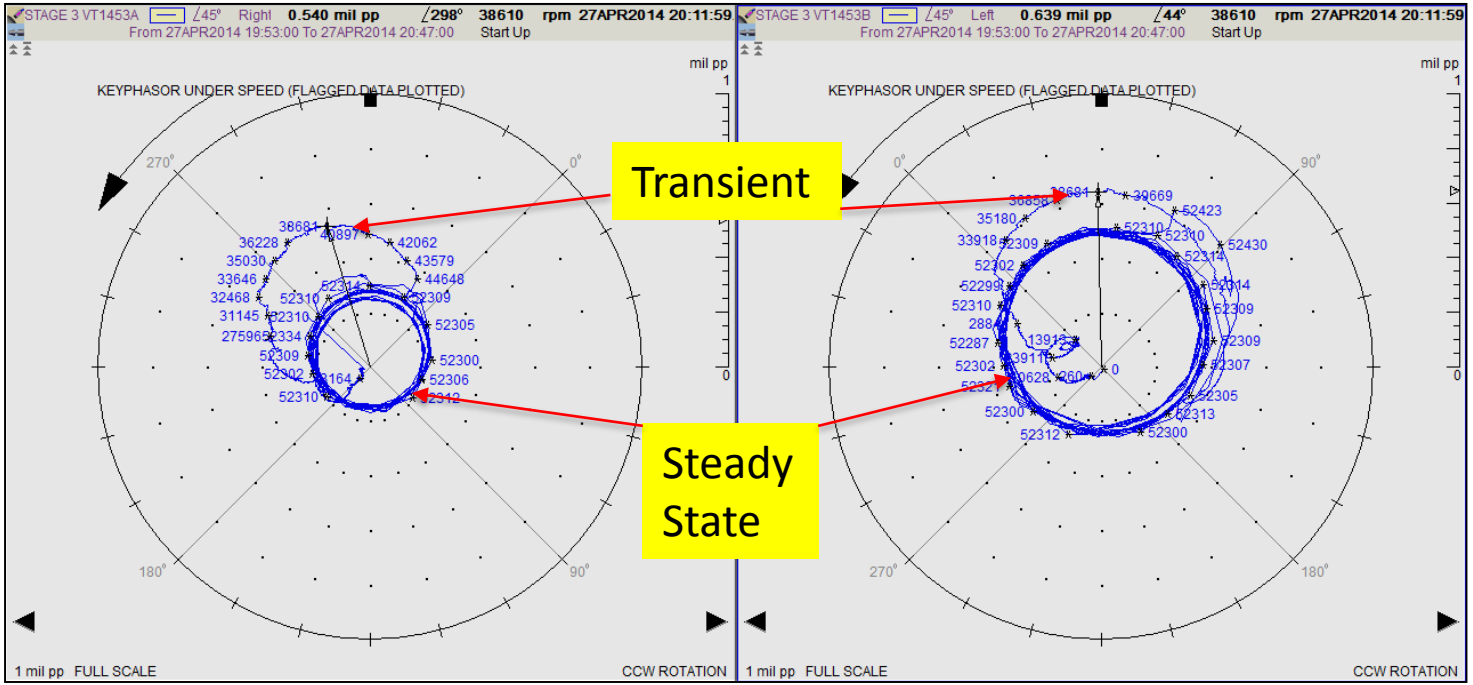


-Transient condition appears normal, where machine reached operating speed with normal behavior

-1X Phase revolution occurs just after reaching operating speed during steady state

Observations/Analysis

Transient & Steady State- 1X Polar Plots of 3rd Stage Bearing:



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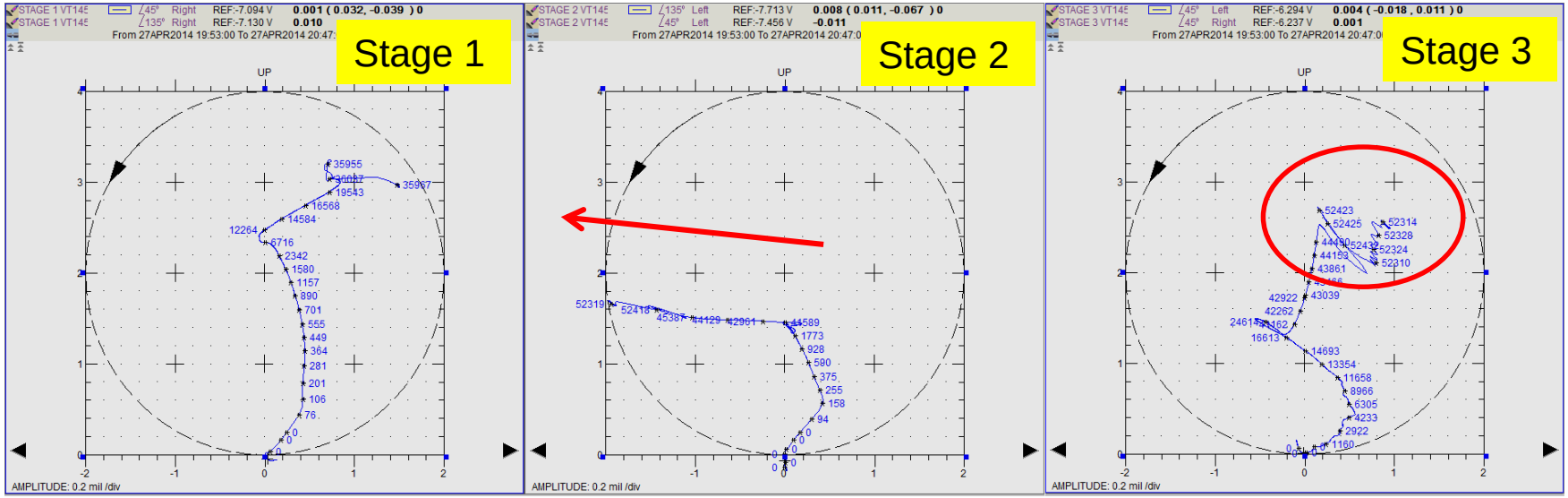
Observations/Analysis

Shaft Centerline Plots



Stage-2 & 3 rotor shows abnormal shaft centerline movement.

Suspected rubbing with the carbon seals on stage 2 & 3 as evidenced from the rotor bouncing at steady state, particularly on stage 3.

Conclusions & Recommendations

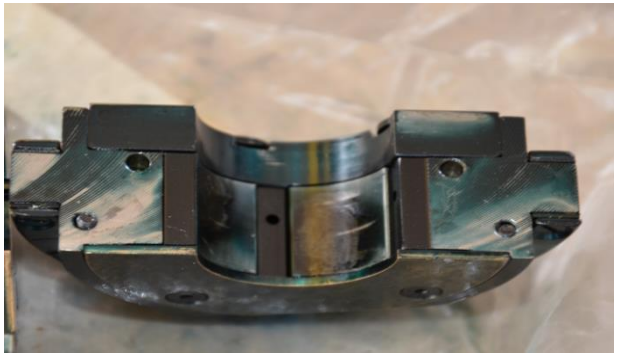
Conclusions:

- Detailed analysis indicates that the vibration is real and not due to instrumentation error.
- Third & Second Stage bearings show typical rub induced vibrations that can be sufficient enough to create localized heating of the rotor causing it to bow.
- The shaft centerline lift during transient condition indicated abnormal gear forces due to misaligned gear assembly causing rubbing of rotor with carbon seals.

Recommendations:

- Investigate the qualitative analysis of oil (viscosity, moisture etc.)
- Verify the alignment condition of the gear assembly with the protocol values.

Machine Inspection Findings



Brownish oil burn marks on 2nd & 3rd stage bearings and rubbing marks on the pinion rotors observed.

Suspected Reasons:-

- *Carbon Seals rub due to mis-alignment across the gears.*
- Burnishing is suspected due to shear stresses in the oil causing high temperature.

Corrective Actions / Lesson Learned

Corrective actions:

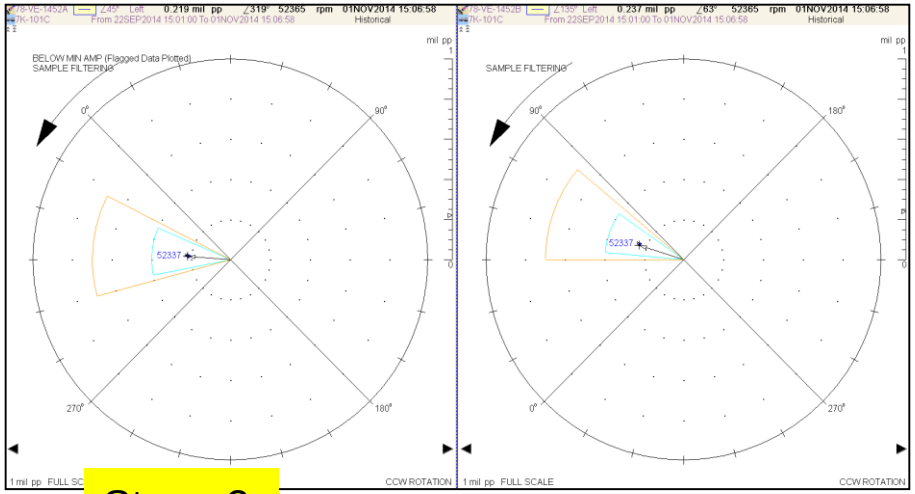
- All the pinion rotors were replaced with new rotors.
- All the bearings were replaced.
- Alignment of the integral gear assembly was carried out.
- Lubricating oil was replaced per the recommendation from OEM. The oil type was changed in terms of viscosity (higher to lower viscosity).

Lessons learned:

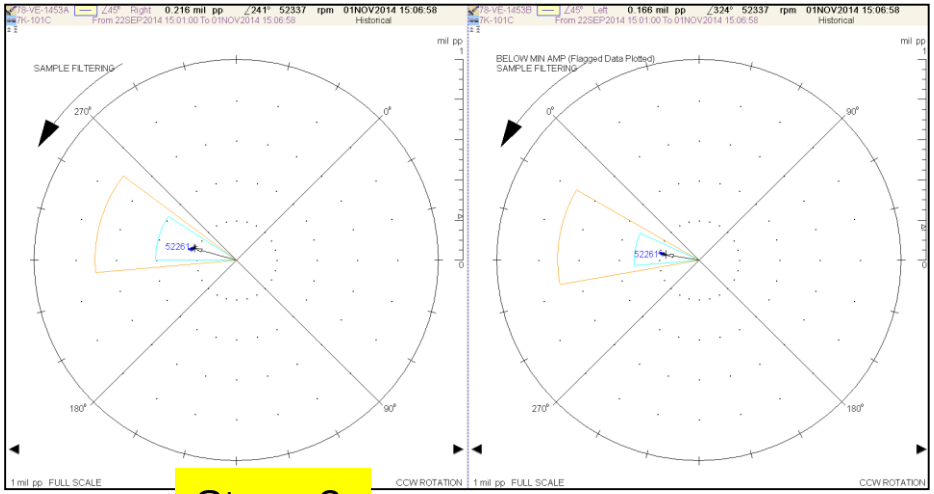
- Oil degradation can lead to shear stresses in the oil lubricant. Hence monitoring of oil quality is also an essential activity.
- Availability of historical information from online condition monitoring system enabled identification of the root cause.

Post Maintenance Data Plots

1X Polar Plots of 2nd and 3rd Stage bearings:



Stage 2

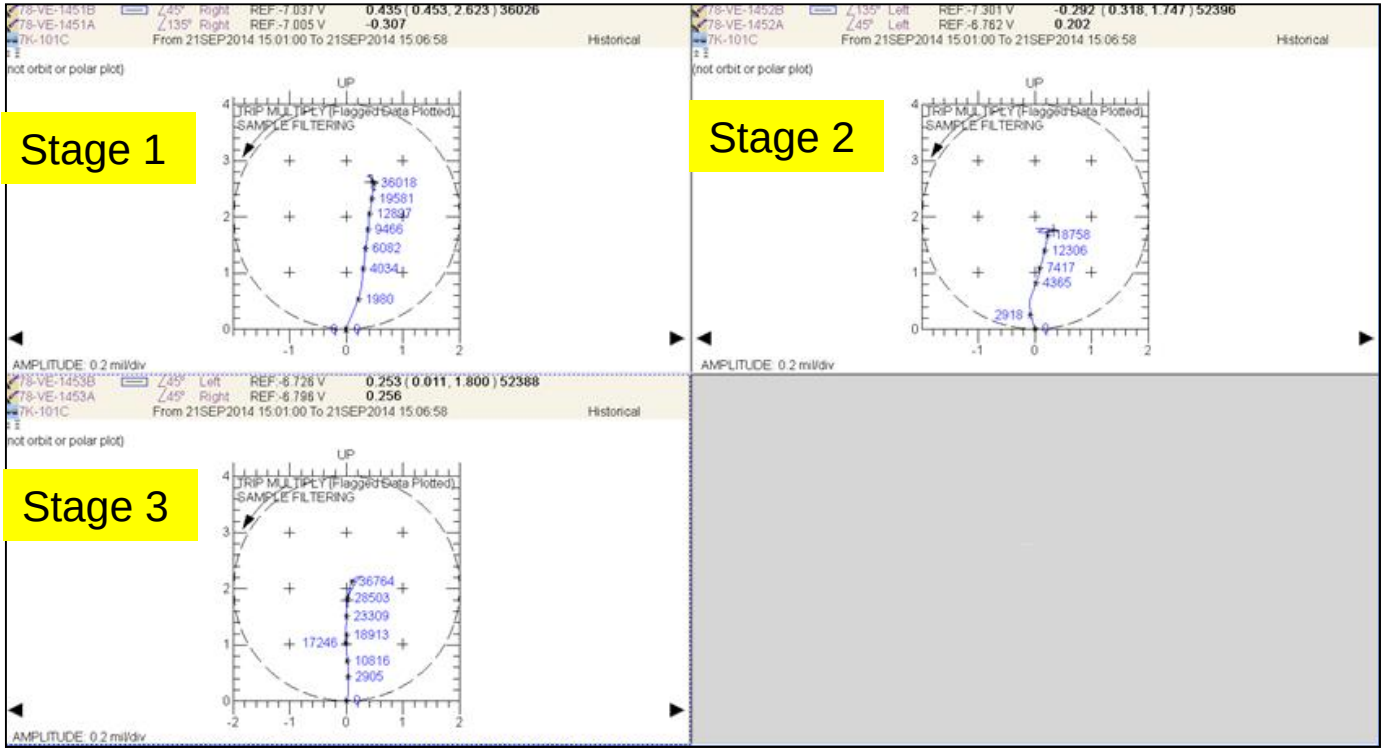


Stage 3

Stable 1X amplitudes/1X phase observed at stage 2 & 3 bearings.

Post Maintenance Data Plots

Shaft Centerline Plots



Normal Shaft Centerline lift observed for all of the pinion rotors after the corrective actions.

QUESTIONS…